Total Productive Maintenance (TPM) targets zero

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"TPM is not a maintenance program ... It is an Equipment Management Program. Equipment Improvement Activities include improving maintainability which requires not only implementing condition monitoring, but also continuously improving condition monitoring methods."

Spokesman for Xerox Semiconductor, U.S., at the 4th Annual Total Productive Maintenance Conference and Exposition, September 1993.

Machinery is so important to most processes that any downtime impacts output. Even so, Machinery Maintenance and Production are separate functions at most companies. Total Productive Maintenance (TPM) is a machinery management philosophy based on the idea that machinery maintenance is an inseparable part of the manufacturing process. In a TPM program, some or all machinery maintenance tasks are performed by the Production Department. The Maintenance Department is either absorbed into the Production Department or is refocused on long-term maintenance prevention techniques.

TPM is a paradigm shift. Its two goals are zero mechanical breakdowns and zero product defects. When breakdowns and defects are eliminated, equipment operation rates improve, costs are reduced, inventory can be minimized, and, as a consequence, labor productivity increases.

The origin of TPM

Total Productive Maintenance grew out of Productive Maintenance (PM), a strategy developed in the 1950s and 60s, primarily in the United States. The U.S. defense and aerospace industries drove its development because of their need for the highest level of reliability. At that time, Productive Maintenance was time-based maintenance featuring periodic servicing and overhaul. In the 1970s and 80s, as manufacturing became increasingly automated, machinery management gained importance. Productivity, cost, inventory, safety and health, production output and quality all began to depend on machine condition.

In Japan, companies began adopting Productive Maintenance and adapting it to their industrial environment. Japanese companies added "people" to the strategy, and made equipment maintenance every person's responsibility. The companies increased each person's motivation and competency, and created a supportive work environment. The Japanese called the new strategy Total Productive Maintenance. In TPM, "Total" has three meanings:

1. *Total effectiveness.* A TPM program's ultimate aim is to maximize profitability.
2. *Total maintenance system.* TPM is a system of maintenance prevention, improved maintainability, and preventive and predictive maintenance.
3. *Total participation of all employees.* A central feature of TPM is machine maintenance performed autonomously by operators through small group activities.

Toyota, the first major company to implement TPM, credited it with reducing process setup times from 4 hours to 10 minutes.

How TPM works

In a TPM program, machine maintenance is analogous to preventive medicine. A machine's proper "diet and hygiene" is attended to, and the machine receives, "periodic checkups by specialists," so problems get early detection and treatment. Daily maintenance, such as cleaning, lubrication and minor adjustments, is the machine operator's responsibility. Maintenance personnel are responsible for periodic audits and preventive repairs.

The first step in improving machine performance is to eliminate failures in equipment currently being operated. TPM uses five countermeasures to help eliminate equipment failures:

- Maintaining well-regulated conditions (cleaning, lubricating and bolting).
- Adhering to proper operating procedures.
- Restoring deterioration.

Total Productive Maintenance:

- Overall Equipment Effectiveness is maximized.
- A thorough system of PM is established for the equipment's entire life span.
- Every department in the company is involved
- Every employee in the company is involved
- Operators perform maintenance on their machines.

mechanical breakdowns and zero product defects

"We are counting on TPM to help us meet our goal of creating a Total Integrated Refinery through advanced automation. The goal is to achieve two years between shutdowns."

Spokesman for Idemitsu Refinery, Japan, at the 4th Annual Total Productive Maintenance Conference and Exposition, September 1993.

- Improving weaknesses in design.
- Improving operation and maintenance skills (training).

TPM's goal and how it is measured

TPM's goal is to eliminate all failures, defects and other negative phenomena — the Six Big Losses. It relies on a measure that accounts for all Six Big Losses, Overall Equipment Effectiveness (OEE). OEE accounts for losses due to equipment downtime, slowed production and product defects. Availability is its measure of losses due to equipment downtime; performance efficiency is its measure of losses due to slowed production, and rate of quality products is its measure of losses due to product defects.

TPM's Six Big Losses

Downtime losses

1. Equipment breakdowns
2. Equipment setup and adjustment time

Slowed production losses

3. Idling or minor stoppage
4. Reduced speed

Product defect losses

5. Process defects
6. Reduced yields

Availability

Many companies measure "rate of equipment effectiveness," however, this measure is not the same as Overall Equipment Effectiveness. Usually, "rate of equipment effectiveness" is availability, as defined in TPM. Availability accounts for a machine's losses due to downtime, in a ratio of actual operating time to scheduled operating time.

Availability alone doesn't accurately reflect equipment operating conditions. Of the Six Big Losses, availability accounts only for those due to downtime, and not those due to slowed production or product defects.

Performance efficiency

TPM uses performance efficiency to account for losses due to slowed production. Performance efficiency is the product of operating speed rate and net operating rate. The operating speed rate accounts for the discrepancy between a machine's design (or ideal) and actual operating speeds. The operating speed rate is the ratio of ideal to actual cycle time, based on the time a machine takes to process a single item. The net operating rate accounts for losses due to small problems and adjustments, and is the ratio of actual processing time to actual operating time.

Rate of quality products

The third factor in OEE is the rate of quality products. It is simply the ratio of items produced with no defects to total production.

Overall Equipment Effectiveness

OEE is the ultimate measure of a TPM program; it is the product of availability, performance efficiency and rate of quality products. Based on the experience of successful TPM companies, the ideal factors for Overall Equipment Effectiveness are:

Availability — greater than 90%

Performance efficiency — greater than 95%

Rate of quality products — greater than 99%

Successful TPM companies have an Overall Equipment Effectiveness rate greater than 85%.

Two factors are critical for accurate OEE calculations, and, therefore, "profitable TPM": Accurate equipment operation records and precise scales for measuring equipment operation.

TPM and Bently Nevada — Move data not people

The TPM philosophy fits very closely with Bently Nevada's. We have long advocated online systems, the kind required for an effective TPM program. We build the industry's most reliable transducers, monitors and diagnostic equipment - including online systems for continuous and periodic monitoring.

As an example, listed below are three requirements of a TPM program and how Bently Nevada can help you fulfill them.

TPM's emphasis on total involvement requires data that is accurate and available to all departments. ►

- The most accurate raw vibration data comes from permanently-installed sensors. Bently Nevada's reputation was founded on accurate vibration sensors for all appropriate vibration measurements.
- Bently Nevada computerized, online data acquisition and analysis systems communicate with most DCS and plant computers. Our Transient Data Manager® 2 System continuously acquires and reduces data from critical machinery during both transient and steady state operation. Our Trendmaster® 2000 for Windows system periodically acquires and reduces data from general-purpose machinery.
- Bently Nevada systems are easy to learn and simple to operate. Our Engineer Assist™ expert system even helps analyze machine data automatically, generating reports that analyze machine problems, providing supporting data and recommending operation and repair options.

Accurate equipment operation records are required.

- An online system with automatic data storage is the best system for maintaining accurate equipment operation records. Current and historical machine records help identify problem areas for root cause analysis and improvement. Bently Nevada is the global leader in online machinery information systems.
- Accurate records are also required by OSHA 1910.119 regulations.

Personnel must be trained and their competency certified.

- We have held training courses around the world for twenty-six years. We have a wide variety of certification training courses in both machinery diagnostics and product operation and maintenance. We now offer Computer-Based Training courses on disk. ■

References:

1 Seiichi Nakajima, "Introduction to TPM," Productivity Press, Cambridge, Massachusetts, 1988.